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L. C.

AN

ACCOUNT

OF THE

SALT SPRINGS AT SALINA,

IN

ONONDAGA COUNTY, STATE OF NEW-YORK;

WITH A

Chemical Examination

OF THE

WATER AND OF SEVERAL VARIETIES OF SALT

MANUFACTURED AT SALINA AND SYRACUSE

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14307

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TO THE HONOURABLE

STEPHEN VAN RENSSELAER,

WITH

SENTIMENTS OF THE HIGHEST RESPECT

FOR

HIS CHARACTER AND DISTINGUISHED EXERTIONS

TO

Advance the Interests of Science,

THE

FOLLOWING PAGES ARE INSCRIBED,

BY

THE AUTHOR.

NOTICE.

THE following Account of the Salt Springs at Salina was originally published in No. 13 of the New-York Medical and Physical Journal, edited by Drs. JOHN B. BECK, PEIXOTTO, and BELL.

AN ACCOUNT, &c.

THE Salt Springs at Salina, whether considered as a source of revenue to the State, or of wealth to its inhabitants, are deserving of the highest consideration. It is very desirable, therefore, that we should possess the most accurate information concerning their chemical composition and their geological relations, as well as those artificial causes which affect either the quality or the quantity of the salt which they produce. Their origin should also be inquired into, with all the lights that can be afforded by experiment and observation. This indeed appears to me to be the most important object embraced in such a course of investigation. If the facts which have already come to our knowledge, are such as to lead to the belief that these springs are formed by the solution of rock salt, the State, as well as individuals, might with less risk incur the expenses attendant upon a search for this useful mineral. But if on the other hand, these facts go to disprove the existence of rock salt, all these subterraneous explorations may, at least for the present, be suspended.

It occurred to me that an examination of the Salt Springs, embracing the above objects, but more particularly their chemical composition, would prove of general interest ; and the more so, as the notices of them hitherto published are so extremely imperfect and unsatisfactory. To effect this purpose I have several times visited these springs ; made preliminary experiments upon the spot, and completed the analyses upon my return. I have as much as possible studied accuracy and precision, and have seldom depended upon the bare assertions of others. Much assistance, however, has been derived from the papers heretofore published, on the salt springs and manufactories of Salina, and from various reports made upon these subjects to the Legislature of our State. Among the most valuable of these are, "A memoir on the Onondaga Salt Springs, and the Salt Manufactories in the States of New-York," by the late Dr. Benjamin Dewitt.* Manuscript reports to the Legislature by Drs. Noyes and T. Romeyn Beck :† and, " An Essay on Salt," by Dr. Jeremiah Van Rensselaer.

* Transactions of the Society for the promotion of Agriculture and the Arts, vol. I. p. 268.

† The communication of Dr. T. R. Beck, was made in answer to sundry queries of a committee appointed by the Legislature of 1821, of which Simeon Ford, Esq. the present superintendant of the State works at Salina, was chairman. This gentleman carries into his office, a scientific and practical knowledge of the subjects connected with the manufacture of this important article, which must be productive of very beneficial results. The answers to these queries contain a very comprehensive view of the methods of manufacture pursued in foreign countries, and many useful sug-

Description of the Springs.

The Salt Springs which I am about to notice, are situated in the State of New-York, at the head of Onondaga Lake, in the county of the same name, about one hundred and thirty miles west of Albany.

This lake is about six miles in length, and one mile in width, and although surrounded on every side by the strongest salt springs, its water is perfectly fresh in every part of its surface. The brine being specifically heavier than the fresh water, falls to the bottom, and can be obtained from thence by sinking a closed bottle, and then withdrawing the cork.

The borders of Onondaga Lake are usually marshy, and sometimes quite heavily timbered. At Salina, the marsh is of considerable extent, and many plants are observed to grow in it, which are also found in the salt marshes on the sea coast, and not elsewhere; as *Salicornia herbacea L.* *Salsola salsa, Mx. &c.* This fact appears to strengthen the opinion adopted by Decandolle and others, that vegetation is in every case the product of the joint influence of temperature, soil, and the particular composition of the moisture of the earth.* Upon the theory of Linneus, that all plants have descended from a few parent stocks, and that they have been distributed

gestions, the recent adoption of which has had the effect of greatly improving the quality of the Onondaga salt.

* Elements of the philosophy of plants by Decandolle and Sprengel, p. 283.

from one point on the surface of the earth to all its parts, we should be at a loss to account for the existence of these plants in situations so remote from each other, when they do not flourish at any intermediate points.

Among the vegetable productions with which this region abounds, I noticed a rare species of *Ranunculus*, *R. cymbalaria* of Pursh, and which is characterized as follows:—*Root* perennial. *Stem* filiform, creeping, sending out roots at the joints. *Leaves* on long petioles, somewhat reniform, obtusely 5-toothed, cordate at base. *Peduncle* radical, 4 to 6 inches high, solitary, 2—5 flowered. *Flowers* pale yellow, small. *Petals* linear. *Fruit* oblong. *Flowers* in July.

It is in the marsh just noticed, that the most valuable salt springs are found. Those which are most strongly impregnated are at Salina, although inferior ones are quite numerous in various parts of the marsh. They issue from the black soil of which it is composed, by small orifices, and at the distance of a few feet from the surface. Reservoirs are constructed at different places near these springs for the convenience of the manufacturers; and from these, by the agency of pumps, the water is conducted through pipes to those works which are at a distance from them.

Geological Situation.

THE surface of the valley of the Onondaga, is several feet below the level of the adjacent plains. The first three or four feet consist of a black mud, which is very soft, and is made up for the most part of decayed vegetable matter. Below this is a stratum of earthy marl, from three to twelve feet in thickness, and containing several interesting organic relics, chiefly shells; of which I collected the following, viz.

<i>Cyclas postumia,</i>	<i>Helix perspectiva, Say.</i>
<i>Planorbis trivolvis,</i>	<i>Helix tridentata,</i>
<i>Planorbis bicarinatus,</i>	<i>Helix thyroideus,</i>
<i>Planorbis campanulatus,</i>	<i>Helix abolabris,</i>
<i>Melania virginica,</i>	<i>Unio ventricosus,</i>

together with a new species of *Paludina*, which had been previously discovered by my friend Mr. James Eights, and which will be noticed elsewhere.

A specimen of this marl yielded, upon a careful analysis, the following results in one hundred grains.

Carbonate of Lime	-	-	83	grs.
Silex	-	-	-	10
Alumine	-	-	-	7
				—
			100	

Every where imbedded in the marl are to be seen nodules, masses, and even continuous strata of indurated clay, containing fragments of decayed or charred wood. It is often so

solid as to present the appearance of a rock formation, and below the marl it alternates with layers of quicksand, and continues, according to Mr. Byington, to the depth of eighteen feet.* After this we reach a conglomerate, composed of rounded pebbles from one to two inches in diameter. It is probable that this continues for some distance, although it has hitherto been explored but five or six feet.

According to Professor Eaton, the saliferous rock forms the floor of all the salt springs of the canal district. This rock is about 150 miles in length, and something more than twenty miles in breadth on an average, extending from near Little Falls, to the west end of Lake Ontario. It descends like an inclined plane to the Genesee River, where it is about two hundred and fifty feet lower than at the ridge between Little Falls and Utica, where it crosses out and terminates.†

Before leaving this part of my memoir, I should notice a remark which I find in Dr. Van Rensselaer's *Essay on Salt*. It is, that "abundance of gypsum has been found associated with the salt in the same manner as has been observed in Europe."‡ Observation has not satisfied me of the correctness of this assertion. Indeed, as Mr. Eaton remarks, gypsum is never associated with the salt formation in the canal district. "I am aware," says he, "that it has often been as-

* Document B. accompanying the report of the Commissioners appointed to perform certain duties relative to the salt springs in the county of Onondaga, made to the Legislature March 18th, 1825.

† *Geological and Agricultural Survey of the district adjoining the Erie Canal.* Part I. p. 103—4.

‡ *Essay on Salt*, p. 31.

serted, that gypsum and salt are two constant associates in the State of New-York. But there are certainly three distinct strata, including the iron formation, between those which contain the gypsum and the salt where they approach the nearest, between Oneida Lake and Genesee River."*

Origin of the Springs.

SEVERAL theories have been suggested to explain the origin of salt springs. By some it is maintained that they proceed from strata, which absorbed the salt waters of the ocean while they stood over the earth. While these waters have been gradually draining down into the lowest cavity, what is left would become less dilute ; and as it would constantly increase in saltiness, the brine in some places would be brought to the strength necessary for crystallization, and hence rock salt would be formed. According to this theory, solutions of rock salt are not admitted for the supply of these springs, which last is the commonly received opinion with regard to their formation. This opinion receives great support from the fact, that brine springs are usually found reposing upon strata of rock salt. In our state, however, no rock salt has hitherto been discovered ; and from the fact, that the saliferous rock has been accurately examined to a great depth,

* Canal Survey, p. 113.

Mr. Eaton is led to infer that it does not exist. He suggests the idea, that this rock and some of the overlaying strata contain the elementary materials, and "that the brine springs are the daily productions of Nature's laboratory."* This I observe is also the theory of M. Patrin, who supposes that salt is daily formed in the rocks or springs. The Chevalier de Bray, in his "Voyage en Tyrol," is of Patrin's opinion, and cites the numerous abandoned galleries which are narrowed by the efflorescence of salt.† For the purpose of testing the correctness of this theory, so far as it relates to the springs at Salina, I have analyzed specimens of the saliferous rock from different localities, and in none have I been able to detect the elementary materials of muriate of soda. Other considerations appear to me to render such a supposition altogether improbable. 1st. The saliferous rock is found in various parts of the United States unaccompanied by salt springs. 2d. If this rock contained the elementary materials of muriate of soda, in such proportion as to form these brine springs, we should every where, or at least occasionally, see it covered with crystals of this salt; but this is not the case. 3d. If the saliferous rock contains muriate of soda, or its elements, it has been incorrectly described by all our writers

* Canal Survey, p. 109.

† Mineralogie appliquée aux arts, par C. P. Brard. vol I. For extracts from this work, I am indebted to Dr. Dekay of New-York, a gentleman well known to the scientific world. I have derived much assistance in the present undertaking, from a perusal of his manuscript collection of "Facts and Observations drawn from various writers on the subject of Salt."

on geology, who assert that it consists essentially of siliceous particles, united by an argillaceous cement.

Is it not more rational to refer the origin of these springs to a stratum of rock salt ? The circumstance of its not having been heretofore discovered, although several strata below the saliferous are exposed on the canal route, is, in my opinion, no argument against its existence ; for it may be, and no doubt is, confined in its locality to the vicinity of the springs. The question is far from being settled ; but of all the theories which have been suggested, the latter appears to me the most plausible. And if the facts which we possess are not yet sufficient to prove its correctness, it is at least free from those objections which bear with so much force upon all the other explanations which have been attempted.

Chemical examination of the brine.

THIS was conducted with a view,
1st, to ascertain the nature of its ingredients ; and,
2d, to determine the proportions of these ingredients, and
their combinations.

To fulfil the first intention, the following experiments were tried either at the springs or upon portions of the water obtained from thence, after having been carefully sealed up in bottles.

I. Infusion of litmus was *reddened* when poured into brine recently taken from the spring, but this effect was not produced when it was gently boiled, or when it had been exposed for some time to the air. Hence I inferred the presence of free carbonic acid. This is moreover evident by the bubbles which rise to the surface of the water, at which the gas can be collected into receivers and submitted to experiment. It is formed at the bottom of the spring, and passes through the water, but as Dr. De Witt correctly remarks, “does not appear to incorporate with it, or at least not in any perceptible degree ; for the brine has none of that sparkling brightness, nor the pungent odour, so characteristic of carbonated waters.” On this account I made no experiments to ascertain its quantity.

II. As the above trial also satisfied me that no other uncombined acid existed in the brine, I was next desirous to test the presence of alkalies. For this purpose papers stained with the infusion of turmeric were suffered to continue for some hours in a portion of the brine ; their intense yellow colour was not in the least affected. But upon the addition of a minute quantity of either of the alkalies, it instantly changed to a reddish brown.

III. Tincture of nut-galls and prussiate of potash were added to different portions of brine, without being followed by any change of colour. These tests would have satisfied me that no iron was contained in the water, had I not observed that Dr. Noyes, in his analysis, states oxide of iron to be one

of its ingredients.* Although not noticed by any other chemist, I thought it of consequence to make further experiments. As Mr. R. Phillips has ascertained that when iron is in a state of peroxide, lime prevents the action of the tincture of nut-galls,† I therefore added to a phial of the brine a small quantity of oxalic acid, and to the filtered liquor applied the gall-test after the manner adopted by Klaproth in his analysis of Carlsbad water, as follows: A slice of the gall-nut was suspended by a silken thread in the brine, and suffered to remain for some days, but no dark cloud was to be observed surrounding this re-agent.

From all these experiments we may safely conclude that iron forms no part of the brine at salina.

IV. Muriate of barytes produced a white precipitate which was partly dissolved by muriatic acid; hence I inferred the presence of sulphuric and carbonic acids in combination with alkaline or earthy bases.

* Dr. Noyes estimates forty gallons, or three hundred and fifty-five pounds avoirdupois of brine to produce fifty-six pounds of saline extracts: of which is

Pure Muriate of Soda	51.00
Carb. of Lime coloured by Oxide of Iron	0.06 $\frac{1}{2}$
Sulphate of Lime	2.04
Muriate of Lime	1.12 $\frac{1}{2}$
Muriate of Magnesia perhaps.	

Van Rensselaer's Essay, p. 33.

Is it not probable that the iron, which is here credited to the brine, was derived from the kettle in which the analysis was conducted?

* Analysis of Bath waters.—*Phil. Mag.* No. 24. p. 349.

a. The following experiment proved that the carbonic acid just detected was combined with lime. A glass vessel full of the brine was boiled for some minutes; a precipitate fell down, a part of which when dried, dissolved with effervescence in dilute muriatic acid, and this dilute solution gave a copious precipitate upon the addition of oxalate of ammonia.

V. Nitrate of silver afforded a very copious white precipitate, indicating the presence of a large proportion of muriatic acid.

VI. Oxalate of ammonia instantly produced a dense white cloud, proving the existence of lime.

VII. To a fresh portion of brine freed of its lime and sulphuric acid by oxalate of ammonia and muriate of barytes, was added phosphate of soda and carbonate of ammonia; a precipitate was immediately produced, proving the presence of magnesia.

Several other experiments were tried with a view of ascertaining completely all the ingredients of the brine, but they led to no further discoveries, and it is therefore unnecessary to detail them.* As it is however stated, by Dr. McNevin, that *potash* exists in this water, and that the sulphuric acid, instead of being united with lime, is in combination with that

* It being perfectly well known that soda is one of the constituents of the brine, it was needless to prove it by experiment in this place.

alkali,* it may be proper to detail the experiments which satisfied me that the assertion was unfounded. This was indeed rendered sufficiently improbable by the fact that sulphate of potash is so easily decomposed by the muriates of lime and magnesia, both of which are allowed to exist in the Salina water. The occurrence of this salt in mineral waters is moreover extremely rare, and I can find no mention of it in any of the tables of their composition which I have examined. But to proceed to the experiments.

a. To a test glass filled with brine, somewhat concentrated by evaporation, tartaric acid was added in considerable quantity. It remained for some time without producing the least change. But when the acid was added to distilled water, holding in solution a minute portion of sulphate of potash, a crystalline salt (the supertartrite of potash) immediately collected and fell to the bottom of the glass. The same result was also produced upon the addition of sulphate of potash and the acid to the brine.

* The following are the results of Dr. McNevin's analysis as quoted in the 2nd volume of the New-York Medical and Physical Journal. p. 515.

“ Sulphate of Potassa	2.525.
Muriate of Lime	2.269.
Muriate of Magnesia	2.012.
Muriate of Soda	93.194.
<hr/>	
	100.000.”

The processes by which these results were obtained, have not, to my knowledge, been published; neither are we made acquainted with the precise locality of the spring whence the water was procured.

b. Muriate of platina was dropped into a fresh portion of the brine, and allowed to remain for some time, but it gave no precipitate. This, when perfectly neutral, is one of the most delicate tests of the presence of potash, and the orange-coloured precipitate which it produces, completely distinguishes the salts of potash from those of soda.

c. Thinking it possible that some of the other ingredients of the brine might affect the power of the above tests, the method recommended by Dr. Thomson was pursued.* A measure full of the water was evaporated to about one half, and lime-water added as long as it afforded any precipitate. The liquid, after filtration, was again concentrated by evaporation, and treated with alcohol, and after another filtration, with oxalic acid, carefully added to avoid excess. The water thus freed of earthy salts was mixed with acetate of lime, but no precipitate appeared either before or after the addition of alcohol, which was a sufficient proof of the absence of both the sulphate of potash and of soda. A portion of the purified liquor was also tested with the muriate of platina, but no precipitate followed.

These experiments are, in my opinion, sufficient to prove that sulphate of potash does not exist in this water; it will hereafter be made evident that the sulphuric acid is combined with lime.

I had therefore ascertained that the following substances were contained in the water under examination, viz.

* Thomson's Chemistry, vol. iii. p. 182.

Carbonic Acid, (free and combined.)

Muriatic Acid.

Sulphuric Acid.

Lime.

Magnesia.

Soda (of course.)

The second object of inquiry was to determine the proportions of these ingredients, and the manner in which they were combined. Two methods of analysis were suggested. 1st, to separate the different substances by various solvents ; and, 2d, to determine by precipitants the weights of acids and bases present in the water—to suppose these united in such a manner that they shall form the most soluble salts. These salts, according to Dr. Murray, will constitute the true saline constituents of the water under examination.* But the latter method has been found objectionable in many instances, and although on the whole preferable to the former, I did not adopt it altogether.† The course which I pursued was 1st, To determine by precipitants the amount of acids and

* Dr. Murray Trans. Royal Soc. Edin. vol. viii. p. 205.

† Thenard, after detailing the methods of analysis by various solvents and that of L-r. Murray, remarks—

“ La méthode de M. Murray est bonne, sans doute ; mais je ne la crois pas meilleure que l^e autre : en effet, celle-ci présente tous les avantages de celle de M. Murray, puis-qu'elle permet de connaître isolément les quantités de bases et d'acides ; elle est même plus générale en ce qu'elle ne souffre point d'exception.”—*Traité de Chimie.* iv. 176.

bases ; and, 2d, To determine, by distinct sets of experiments, the manner in which these were combined.

The specific gravity of the brine under examination, was found to be 1.108 ; which, according to the formula of Mr. Kirwan, would give 151.2 saline contents in 1000 parts of water, or 15.1 in 100 parts. In the present instance this proved nearly correct ; for,

A measure of the water, weighing 1000 grains, was evaporated down with much care to dryness ; the residuum being well dried, weighed 156. This served as a standard by which to compare the succeeding results.

To the same quantity of water, after being somewhat concentrated by evaporation, muriate of barytes was cautiously added until it no longer yielded a precipitate. The precipitate was washed until the water gave no cloudiness with nitrate of silver ; it was then dried at a low heat, and found to weigh 10.75. The addition of muriatic acid caused an effervescence, and dissolved a part of the precipitate, denoting the presence of carbonate of barytes. The whole was again washed and dried at the same temperature as before, and upon weighing it, was found to have lost 3.50. This loss may be estimated as the amount of carbonate of barytes, and is equivalent to 0.77 carbonic acid. 7.25 sulphate of barytes is equivalent to 2.46 sulphuric acid.

To the filtered solution containing all the washings and again concentrated, oxalate of ammonia was added, and at length drop by drop, as long as any precipitate was afforded. The precipitate consisting of oxalate of lime was repeatedly washed, then dried and converted into a sulphate, the weight

of which, after being sufficiently heated, was $11.00 = 4.50$ lime.

To the water freed of its lime, carbonic and sulphuric acids, and reduced by evaporation, carbonate of ammonia and phosphate of soda were added. The triple salt, after being washed and dried at a low heat, weighed 5.50, which, according to Dr. Wollaston, is equivalent to 1.12 magnesia.

Having now ascertained the weight of all the ingredients except the muriatic acid and soda, the whole of the water was evaporated to dryness. The residuum, exposed for some time to a moderate heat, was found to weigh 143., which may be set down as muriate of soda = 75. soda.

To ascertain the whole quantity of muriatic acid in a given weight of brine, 100 grains somewhat reduced as before, were mixed with nitrate of silver until precipitation ceased. The chloride washed, dried and heated to a red heat, weighed 37.00, equivalent to 6.92 muriatic acid; or 69.20 in 1000 grains.

These experiments, therefore, gave me the following results, as the constituents in 1000 grains of brine, viz :

Carbonic acid	-	-	-	-	-	0.77
Sulphuric acid	-	-	-	-	-	2.46
Muriatic acid	-	-	-	-	-	69.20
Lime	-	-	-	-	-	4.50
Magnesia	-	-	-	-	-	1.12
Soda	-	-	-	-	-	77.00

My next object was to ascertain the manner in which these acids and bases were united together in binary compounds.

Carbonic Acid.—Experiment II. satisfied me that this acid was not in combination with soda. That it was not united with magnesia, was proved by the fact that after a portion of the water had been boiled for some time, muriate of alumine gave no precipitate. It must, therefore, be combined with lime, and this was moreover proved by the following trial.

A measure of the water was boiled briskly for a few minutes. A precipitate now fell down, which being washed and dried, and afterwards submitted to the action of muriatic acid, effervesced and was partly dissolved. This was thrown into distilled water, which, after filtration, yielded a copious precipitate with oxalate of ammonia. We cannot doubt, therefore, that the carbonic acid is combined with lime, and gives 1.79 carbonate of lime.

Sulphuric Acid.—Experiment c proved that this acid was not combined with soda, and the hydro-sulphuret of strontian satisfied me that it was not with magnesia. It must, therefore, be united with lime. But as the existence of this salt is denied by Dr. McNevin, in his analysis before quoted, and as Dr. Murray supports the opinion, that in most cases in which sulphate of lime is given as one of the constituents of mineral waters, it is formed during the analysis, I was induced to adopt another method to test the correctness of the inference which I had drawn. To a measure of the brine about half its bulk of alcohol, of the specific gravity of .825, was added. A copious precipitate was produced, which, when frequently

washed to free it from muriate of soda, consisted of sulphate and carbonate of lime.*

I do not conceive that the most strenuous advocate of the formula of Dr. Murray, will now object to the existence of sulphate of lime in the Salina water, particularly as it has been shown that the sulphuric acid is not combined with soda or magnesia, which, with lime, are the only bases present. Great care was taken in this part of the analysis that the concentration should not be carried so far as to render the combinations different from those which originally existed in the water. Dr. Murray himself recommends, in all analyses of mineral waters, the previous concentration of the water by evaporation. "This," says he, "renders the action of the reagents which we employ more complete and certain." Now those who have visited the salt works at Salina, Montezuma, or Syracuse, but especially the latter, must have observed that soon after the brine is exposed to the heat of the sun, there is separated a precipitate of a beautiful crystalline structure, which is insoluble in water, unless added in very large quantities. This precipitate, as will hereafter be shown, consists mainly of carbonate and sulphate of lime. A decomposition, therefore, must take place the instant that evaporation

* "Spirit of wine, which will precipitate every salt with the sulphuric acid out of the water in which it is dissolved, if sufficiently concentrated, possesses this power to a remarkable extent with sulphate of lime; for, as Kirwan observes, it will immediately precipitate one grain of this earthy salt out of 1000 grains, or about two ounces of water; and therefore this is a test of considerable delicacy." *Saunders on Mineral Waters.*

commences, or else sulphate of lime, as such, exists in the water; for it can hardly be conceived that a slight concentration of a mineral water produces no change whatever in the compounds of which it is composed, but that as soon as this is carried a little farther, the whole mass is disturbed, and by the operation of the forces of cohesion and affinity new compounds are formed. It is certainly more rational to conclude in reference to the sulphate of lime, that as it requires a large proportion of water to hold it in solution, whenever this is lessened in bulk by concentration, the salt begins to precipitate, and continues so to do until the whole is separated. The amount of sulphuric acid being 2.46, is equivalent to 4.20 sulphate of lime.

Muriatic Acid. As all the lime was not yet accounted for, it appeared probable that the remainder was combined with muriatic acid. This was also made evident by trials with alcohol, in which the muriate of lime is soluble. The amount of lime remaining is 1.76, equivalent to 3.48 muriate of lime.

By previous experiments, I had learned that the magnesia was not combined with the carbonic or sulphuric acids; it must consequently be with the muriatic. 1.12 magnesia is equivalent to 2.57 muriate of magnesia. Deducting 3.20 muriatic acid contained in the muriates of lime and magnesia from the whole amount (69.20,) leave 66.00 in combination with soda, equivalent to 143.50 muriate of soda.

The following therefore are the binary compounds in 1000 grains of the brine.

Carbonate of Lime,	-	-	-	1.79
Sulphate of Lime,	-	-	-	4.20
Muriate of Lime, -	-	-	-	3.48
Muriate of Magnesia,	-	-	-	2.57
Muriate of Soda,	-	-	-	143.50
				155.54

The weight of the dry residuum from a like quantity of water was - - - - - 156.00

The following are the compounds in 100 grains of the dry salt.

Carbonate of Lime,	-	-	.	1.14
Sulphate of Lime,	-	-	-	2.69
Muriate of Lime, -	-	-	-	2.25
Muriate of Magnesia,	-	-	-	1.54
Muriate of Soda, -	-	-	-	92.38
				100.00

Methods of Manufacture.

Salt is manufactured at Salina and its vicinity in three ways.

1st, By boiling the water in kettles.

2d, By evaporation with artificial heat.

3d, By solar evaporation. I shall notice each of these methods in detail, and make such remarks as may occur upon their comparative advantages.

1st. *By boiling.* The mode pursued in the manufacture of salt by boiling is as follows. From twelve to sixteen iron kettles, such as are used in the manufacture of potashes, are arranged in two parallel rows, and firmly fixed in brick-work over a furnace, constituting what is known as a *block*. These kettles being of a capacity of about 100 gallons, are filled with brine, which is made to boil. As soon as ebullition commences, the water becomes very turbid, and the calcareous salts begin to precipitate. These are repeatedly removed by large iron ladles, which are placed for that purpose at the bottom of the kettles, and are called *bittern ladles*. A proportion, however, adheres to the bottom and sides of the kettles, and after a few days forms a solid coating, called *pan scale*. When the process is properly conducted, this is frequently removed, as its accumulation retards the boiling, and impairs the purity of the salt. Soon after this calcareous matter is deposited, crystals of salt begin to shoot out and sink to the bottom, and this continues until nearly all the water has evaporated. The salt is now removed to proper places for the purpose of draining off the brine, and suffering it to become dry. This completes the work of the manufacturer. The salt made in this way consists of fine grains, more or less hard and pure, according to the care which has been taken in conducting the process.

I should not omit to mention that the Onondaga Company have erected a *block*, containing forty-two kettles and pans, with suitable vats and reservoirs; in which works the water is boiled to saturation, when it is drawn off into vats for

crystallization. This possesses great advantages over the common method.

Some years since the manufacturers were in the habit of throwing lime into the brine as soon as ebullition commenced, for the purpose, as it was said, of promoting the more ready crystallization of the salt. About this time, also, great complaints were preferred against the purity of the salt ; and the employment of this article was generally assigned as the cause. At present its use is probably quite limited, as it has been rendered a penal offence, by a recent act of the legislature. Still, however, it is maintained by manufacturers of great experience, that the addition of lime occasions a more speedy precipitation of the calcareous compounds contained in the water ; expedites the manufacture of the salt, and does not, in the least, impair its purity.* This being a subject of some importance, I was desirous to test the correctness of the above statements ; and I had a good opportunity of doing so, by observing the effect of lime water upon a portion of the brine. I conceive its operation to be as follows : the lime unites with the carbonic acid, which escapes as soon

* "The use of lime to produce the more ready crystallization of the salt, appears to be confined to Salina ; for no notice of it is to be found in any of the histories relating to the manufacture of salt, except in a paper by M. Berthier, giving an account of the manufacture of salt, at Moutiers, in France. (*Repertory of Arts, Second Series, Vol. XVII. p. 231.*) It is there mentioned that Gren, a German Chemist, recommended the addition of a cream of quicklime to the brine, under certain circumstances. But the very circumstances stated are sufficient to deter from its use."—*Dr. T. R. Beck's MS. Report.*

as ebullition commences, forming a carbonate of lime, which immediately falls to the bottom. The original portion of carbonate of lime contained in the water being thus deprived of the excess of carbonic acid which held it in solution, is also precipitated, and with it, the whole, or a part, of the magnesia. We have then remaining, after these precipitations, lime in solution, (the amount depending upon that which was originally added,) and the muriatic acid which has been freed from its union with magnesia. This acid is probably saturated with lime, and the remaining portion of the latter is either converted into a carbonate and is precipitated, or else is incorporated with the salt. The addition of lime does not, I apprehend, increase the quantity of earthy muriates, and it is to these chiefly that the impurity of salt is to be ascribed.* If

* The principal objection to the salt made by boiling, is the large proportion of earthy muriates which it usually contains. This is chiefly caused by the hurried manner in which the process is conducted. The following quotation from Chaptal is in point.

“ Since the suppression of salt taxes,” (in France,) says he, “ and that the salt trade is laid open, the proprietors of such works dispose of their salt before it has undergone a sufficient degree of purification. It appears to me to be necessary to enlighten the public mind respecting the difference between recent salt and that which has undergone depuration, and been well drained from the brine and bittern.

“ Recent salt is bitter and deliquescent, whereas that which has been kept for a length of time, is of a penetrating taste, possesses solidity, and does not deliquesce on exposure to a moist atmosphere.

“ Hence it appears that recent salt is not well adapted for preserving meat and similar purposes: it imparts to them not only a bad taste, an

these views are correct, it follows that no great evil can result from the use of a small quantity of lime, provided the boiling be moderate, and sufficient care be taken to remove the deliquescent compounds by washing and drying the salt. But as it was generally employed by those whose only object is to obtain the largest amount of salt in a given time, without any regard to its purity, it is perhaps with propriety interdicted.

It has been observed that the earthy salts contained in this water, precipitate and form a coating to the kettles, which should be frequently removed. A specimen of this pan scale of great solidity was analyzed after the manner presently to be detailed. Its composition proved to be as follows, in 1000 grains, viz. :

Muriate of Lime,	-	-	-	-	11
Muriate of Magnesia,	-	-	-	-	4
Carbonate of Lime,	-	-	-	-	60
Sulphate of Lime,	-	-	-	-	688
Muriate of Soda,	-	-	-	-	237
					1000

These proportions no doubt vary greatly in different specimens.

vitiates their colour, but prevents their acquiring that firmness which is essential to their preservation. Recent salt is, moreover, subject to great waste during its conveyance to any distance, as it relents in a moist air, and runs per deliquum."—*Chaptal's Chemistry applied to the Arts.* Vol. IV. p. 169.

2d. *By evaporation with artificial heat.*—The investigations which have at different times been made into the causes of the impurity of the salt made by boiling, has had the effect of bringing into notice less objectionable methods. By these, if ordinary care is employed, salt may be manufactured of as good a quality as that of any other part of the world. The works of Mr. Byington bear a close resemblance to those of Cheshire, in England; and the salt manufactured there, which is altogether coarse, is of the best kind. The buildings erected for this purpose are about 130 feet in length, and 50 feet in width. In each of these buildings are three wooden vats, each connected with an iron pan, and these occupy the whole ground, except a few feet at one end. These vats are about two feet deep, and expose a surface of 10,350 square feet of water, and contain, when filled, 105,600 gallons of water, which is kept at a temperature of from 110 to 160 of Fahrenheit. The water is heated by twelve fires, which consume about 180 cords of wood per month, and will produce, in that time, about 4,000 bushels of salt. It requires three men to attend these works; and it is stated that the ashes made in the operation will pay one half the expense of this labour.*

The works of Mr. Rossiter differ somewhat from the preceding, and indeed from any other which I have hitherto seen described. They are situated on the lateral canal, and are

* Mr. Byington's letter to the Commissioners appointed to perform certain duties relative to the Salt Springs in the county of Onondaga, by the Legislature of 1825.

calculated chiefly for the manufacture of coarse salt by artificial heat. The water is first introduced into a large cistern, capable of containing 57,000 gallons, where it remains until it becomes transparent. It is then drawn into a lower cistern of 40,000 gallons capacity, attached to the other, and is there rapidly evaporated to saturation. When all the impurities have subsided and the salt begins to crystallize, the pickle is drawn into a side vat or cistern of 100 feet in length, and of 75,000 gallons capacity, and then dried down by a gentle heat. The heat is applied in large iron cylinders from two to three and a half feet in diameter, which run through all the cisterns, and are entirely surrounded by the water. The two preparing cisterns are calculated to hold raw water sufficient for 2,000 bushels of salt, and the salting cistern will hold saturated water sufficient for 3,000 bushels. These works consume about four cords of wood in twenty-four hours, and produce, in summer, about 200 bushels of salt daily—and about 50,000 bushels yearly.

3d. *By solar evaporation.*—The most extensive solar evaporation works are at Syracuse, although there are some also at Montezuma. Of the former, one half is owned by the Syracuse, and the other half by the Onondaga Salt Manufacturing Companies. These companies were incorporated under the act of April 3, 1821, authorizing them to expend 50,000 dollars each, in the erection of salt works, which, it is believed, will complete for each company, 36,000 feet of vats of eighteen and a half feet wide, making in the whole 72,000 feet in length, capable of producing annually 150,000 bushels of coarse

salt.* The vats constructed for this manufacture, are eighteen and a half feet square, and about a foot deep. Of these, there are two parallel rows, which communicate with each other; the one being on a level about a foot lower than the other. The whole operation is extremely simple. The brine is conducted by wooden pipes into the upper tier of vats, where it remains exposed to the sun until crystals of salt begin to shoot out on the surface. By this time nearly all the lime and other impurities have subsided, and are to be found at the bottom of the vats in beautiful crystals, which are somewhat deliquescent. The brine, thus reduced to saturation, is drawn off into the lower tier of vats, where the formation of salt goes on. It is then taken out and dried, as before, by the heat of the sun; when it consists of large crystals, hard and dry, and of a beautiful white colour. It may be remarked that the evaporation of the water depends greatly upon the state of the atmosphere, and that the process is of course retarded when there is much humidity. But to prevent the embarrassment which would ensue from the access of rains, by the dilution of the brine, covers are constructed for the vats, which run upon rollers, and may be easily moved whenever occasion requires.

The mode just described is certainly less liable to objection than any other, and if properly conducted, leaves no chance for the occurrence of an injurious proportion of foreign substances. All the impurities are allowed to subside

* Report of the Commissioners, &c.

in vats other than those in which the salt crystallizes ; and as the only dependence is upon solar heat, sufficient time is granted for their complete and total separation.

The crystals found in such abundance, in the upper vats, and which have been before noticed, were submitted to analysis ; and were found to consist of the following compounds, in 1000 grains.

Muriate of Lime and Magnesia,	-	8
Carbonate of Lime, -	-	82
Sulphate of Lime, -	-	832
Muriate of Soda, -	-	78

Chemical examination of salt.

WITH a view of ascertaining the relative purity of the salt manufactured in each of the above ways, I submitted three specimens to analysis.* The first made by solar evaporation : the second by evaporation with solar heat, at Byington's works : and the last by boiling in the usual manner adopted at Salina.

* This analysis was made at the request of the Commissioners, appointed for the before mentioned purpose by the Legislature of 1825 ; and the result published in their report.

Having learned by experiments upon solutions of the salt in distilled water, the nature of the compounds contained in it, I pursued the following method :

1. 1000 grains of salt well dried and pulverized, were treated with alcohol of the specific gravity of 825. :—the earthy muriates extracted and separated, according to the method adopted by Dr. Henry, in his “Analysis of British and Foreign Salts.”*

2. The portion of salt which was undisolved by the alcohol, was dissolved in sixteen ounces of distilled water, and the solution filtered ; in no case was there any notable portion of insoluble matter left on the filter.

3. To the filtered solution, carbonate of soda was added, and the liquid briskly boiled for a few minutes, and then again filtered. The carbonate of lime left on the filter, was washed and dried ; its weight indicating the quantity of sulphate of lime which had been decomposed.

4. The filtered solution was neutralized by muriatic acid, and muriate of barytes was added till it ceased to yield any further precipitate. The weight of the sulphate of barytes proved that no other sulphate existed in the salt.

* Repertory of Arts, Vol. XVII. second series.

The salt made by solar evaporation at Syracuse contains, in 1000 grains,

Muriate of Magnesia,	-	-	-	2
Sulphate of Lime,	-	-	-	7
Muriate of Soda,	-	-	-	991
			—	
			1000	

The salt made at Byington's works, contains, in 1000 grains,*

Muriate of Magnesia,	-	-	-	1½
Muriate of Lime,	-	-	-	1
Sulphate of Lime,	-	-	-	9
Muriate of Soda,	-	-	-	988½
			—	
			1000	

* Mr. G. Chilton of New-York, one of our most accurate chemists, analyzed a finer specimen of this salt, and found it to consist of the following compounds in 1000 grains.

Muriate of Magnesia,	$\frac{1}{2}$ gr.
Sulphate of Lime,	5½
Muriate of Soda,	994
	—
	1000

The salt made by boiling in kettles, contains, in 1000 grains,

Muriate of Magnesia,	-	-	-	3
Muriate of Lime,	-	-	-	6
Sulphate of Lime,	-	-	-	11
Muriate of Soda,	-	-	-	980
				1000

It may not be improper to introduce the following table from Dr. Henry's paper above quoted; as it will exhibit the component parts of several varieties of foreign salt, and enable the reader to estimate the great purity of that at present manufactured in our own State :

1000 parts by weight consist of

KINDS OF SALT.	Insoluble matter.	Mur. of lime.	Mur. of Magn.	Sulphate of lime	Sulphate of Magn.	Pure Mur. of Soda.
Foreign { St. Ubes,	9	1 trace	3	23 $\frac{1}{2}$	4 $\frac{1}{2}$	960
Bay { St. Martins,	12	do.	3 $\frac{1}{2}$	19	6	959 $\frac{1}{2}$
Salt. { Oleron,	10	do.	2	19 $\frac{1}{2}$	4 $\frac{1}{4}$	964 $\frac{1}{4}$
British salt { Scotch (common.)	4	—	23	15	17 $\frac{1}{2}$	935 $\frac{1}{2}$
from { Scotch (sunday.)	1	—	11 $\frac{1}{2}$	12	4 $\frac{1}{2}$	971
Sea-water. { Lymington (common.)	2	—	11	15	35	937
Sea-water. { Lymington (cat.)	1	—	5	1	5	988
Cheshire { Crushed rock,	10	1 $\frac{1}{6}$	1 $\frac{1}{6}$	6 $\frac{1}{2}$	—	983 $\frac{1}{4}$
Cheshire { Fishery,	1	1 $\frac{1}{4}$	1 $\frac{1}{4}$	11 $\frac{1}{4}$	—	986 $\frac{3}{4}$
Salt.* { Common,	1	1 $\frac{1}{4}$	1 $\frac{1}{4}$	14 $\frac{1}{2}$	—	983 $\frac{1}{2}$
Salt.* { Stored,	1	1 $\frac{1}{4}$	1 $\frac{1}{4}$	15 $\frac{1}{2}$	—	982 $\frac{1}{2}$





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